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(54) SURFACE ACOUSTIC WAVE DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a surface acoustic wave device the delay time temperature coefficient of which is reduced.

SOLUTION: Single crystal piezoelectric substrates employing the same type of material are joined by taking a propagation direction of a surface acoustic wave in parallel with the direction in which the linear expansion coefficient is small in order to improve the linear expansion coefficient. Or the joining layer of a joined substrate obtained by joining substrates made of different kinds of materials employs a coated glass layer with a high heat resistance and ease of handling.

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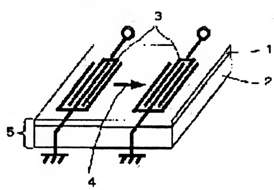

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CLAIMS

[Claim(s)]

[Claim 1] In the surface acoustic element equipped with the tandem-type crossed electrode which is formed on the plane of composition of the 1st substrate which is a single crystal piezo-electricity substrate, the 2nd substrate joined to said 1st substrate, and said 2nd substrate of said 1st substrate, and Men of the opposite side, and excites an elastic wave The coefficient of thermal expansion of said 2nd substrate [in / said 2nd substrate is a substrate of the same quality of the material as said 1st substrate, and / the propagation direction of said elastic wave of said 1st substrate] is a surface acoustic element characterized by being smaller than the coefficient of thermal expansion of this direction of said 1st substrate.

[Claim 2] It is the surface acoustic element characterized by the thickness of said 2nd substrate being 3 or more times of the thickness of said 1st substrate in a surface acoustic element according to claim 1.

[Claim 3] It is the surface acoustic element characterized by for said 1st and 2nd substrates being lithium tantalate, for the Z-axis of said 2nd substrate existing in the plane of composition of said 2nd substrate in a surface acoustic element according to claim 1 or 2, and the propagation direction of said elastic wave of said 1st substrate being parallel to the Z-axis of said 2nd substrate.

[Claim 4] In a surface acoustic element according to claim 1 or 2, said 1st and 2nd substrates are lithium tantalate. Men bearing of said 1st substrate is the direction rotated from the Y-axis to Z shaft orientations focusing on the X-axis at an angle of the range of 36 degrees - 46 degrees. It is the surface acoustic element characterized by for Men bearing of said 2nd substrate being Y shaft orientations or X shaft orientations, for the propagation directions of said elastic wave of said 1st substrate being X shaft orientations of said 1st substrate, and the X-axis of said 1st substrate being parallel to the Z-axis of said 2nd substrate.

[Claim 5] In a surface acoustic element according to claim 1 or 2, said 1st and 2nd substrates are lithium tantalate. Men bearing of said 1st and 2nd substrates is the direction rotated from the Y-axis to Z shaft orientations focusing on the X-

axis at an angle of the range of 36 degrees - 46 degrees. It is the surface acoustic element which the propagation directions of said elastic wave of said 1st substrate are X shaft orientations of said 1st substrate, and is characterized by the X-axis of said 2nd substrate and the X-axis of said 1st substrate crossing at right angles.

[Claim 6] In a surface acoustic element according to claim 1 or 2, said the 1st and said 2nd substrate are lithium tantalate. Men bearing of said 1st substrate is X shaft orientations, and Men bearing of said 2nd substrate is Y shaft orientations or X shaft orientations. The direction which the propagation direction of said elastic wave of said 1st substrate is a direction rotated from the Y-axis of said 1st substrate at the include angle of 112 degrees to Z shaft orientations, and was rotated from the Y-axis of said 1st substrate at the include angle of 112 degrees to Z shaft orientations is a surface acoustic element characterized by being parallel to the Z-axis of said 2nd substrate.

[Claim 7] It is the surface acoustic element characterized by for said the 1st and said 2nd substrate being lithium niobate, for the Z-axis of said 2nd substrate existing in the plane of composition of said 2nd substrate in a surface acoustic element according to claim 1 or 2, and the propagation direction of said elastic wave of said 1st substrate being parallel to the Z-axis of said 2nd substrate.

[Claim 8] In a surface acoustic element according to claim 1 or 2, said the 1st and said 2nd substrate are lithium niobate. Men bearing of said 1st substrate is the direction rotated from the Y-axis at an angle of the range of 41-64 degrees to Z shaft orientations focusing on the X-axis. It is the surface acoustic element characterized by for Men bearing of said 2nd substrate being Y shaft orientations or X shaft orientations, for the propagation directions of said elastic wave of said 1st substrate being X shaft orientations of said 1st substrate, and the X-axis of said 1st substrate being parallel to the Z-axis of said 2nd substrate.

[Claim 9] In a surface acoustic element according to claim 1 or 2, said the 1st and said 2nd substrate are lithium niobate. Said the 1st and Men bearing of said 2nd substrate are the direction rotated from the Y-axis at an angle of the range of

41-64 degrees to Z shaft orientations focusing on the X-axis. It is the surface acoustic element which the propagation directions of said elastic wave of said 1st substrate are X shaft orientations of said 1st substrate, and is characterized by the X-axis of said 2nd substrate and the X-axis of said 1st substrate crossing at right angles.

[Claim 10] It is the surface acoustic element characterized by for said 2nd substrate being a tetraboric-acid lithium single crystal, for the c-axis of the tetraboric-acid lithium single crystal of said 2nd substrate existing in the plane of composition of said 2nd substrate in a surface acoustic element according to claim 1 or 2, and the propagation direction of said elastic wave of said 1st substrate being parallel to the c-axis of the tetraboric-acid lithium single crystal of said 2nd substrate.

[Claim 11] 10 is [claim 1 thru/or] the surface acoustic element characterized by having the glue line to which junction of said 1st substrate and said 2nd substrate uses spreading glass as a principal component in the surface acoustic element of a publication at the junction interface of said 1st substrate and said 2nd substrate either.

[Claim 12] In the surface acoustic element equipped with the tandem-type crossed electrode which is formed on the plane of composition of the 1st substrate which is a single crystal piezo-electricity substrate, the 2nd substrate joined to said 1st substrate, and said 2nd substrate of said 1st substrate, and Men of the opposite side, and excites an elastic wave It is the surface acoustic element which has the glue line which uses spreading glass as a principal component in a junction interface, and is characterized by the thickness of said 2nd substrate being 3 or more times of the thickness of said 1st substrate.

[Claim 13] The surface acoustic element characterized by optimizing the thickness of a spreading glass layer so that the temperature coefficient of the elastic wave velocity of propagation which the glue line which uses said spreading glass as a principal component has in a surface acoustic element given in claim 12 term may serve as a value which offsets the coefficient of

thermal expansion of the propagation direction of said elastic wave of said 1st substrate.

[Claim 14] The 1st process washed after being the approach of manufacturing the substrate for surface acoustic elements claim 11 thru/or given in 13 and heat-treating said the 1st and said 2nd substrate, The 2nd process which evaporates the solvent of spreading glass membrane with heating after applying spreading glass membrane to the plane of composition of said the 1st or said 2nd substrate, The manufacture approach of the substrate for surface acoustic elements characterized by joining said the 1st substrate and said 2nd substrate through a spreading glass layer according to the 3rd process to which said the 1st substrate and said 2nd substrate are joined, and the 4th process which heat-treats after substrate junction.

[Claim 15] They are the lithium tantalate which has Men bearing which said 1st substrate rotated from the Y-axis to Z shaft orientations focusing on the X-axis in the surface acoustic element according to claim 12 or 13 at an angle of the range of 36 degrees - 46 degrees, the lithium tantalate which makes the X-axis field bearing, or the surface acoustic element characterized by being lithium niobate which has Men bearing rotated at an angle of the range of 41-64 degrees to Z shaft orientations from a Y-axis focusing on the X-axis.

[Claim 16] It is the surface acoustic element characterized by said 2nd substrate consisting of either or those composite material of a diamond, alumimium nitride, silicon, oxidization silicon, silicon nitride, boron, oxidization boron, boron nitride, lithium tantalate, lithium niobate, and a tetraboric-acid lithium in a surface acoustic element according to claim 12 or 13.

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2.**** shows the word which can not be translated.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the manufacture approach of the component using the surface acoustic wave used for a cellular phone etc., and its substrate.

[0002]

[Description of the Prior Art] The surface acoustic element used for a cellular phone etc. is the Institute of Electronics, Information and Communication Engineers paper magazine A and J76 volume. - The Kushigata crossed electrode of a metal thin film is formed on single crystal piezo-electricity substrates, such as a lithium tantalate substrate, a lithium-niobate substrate, and a tetraboric-acid lithium substrate, and it is constituted as shown in A, No. 2, and 185 - 192 pages (February, 1993).

[0003] The report which made the time delay temperature coefficient of the substrate for surface acoustic elements used for them improve is made with high-performance-izing of a cellular phone etc. For example, there is an example to which the single crystal piezo-electricity substrate and the glass substrate were directly joined as shown in JP,11-55070,A. Furthermore, there is an example which joined minus expansion glass to the single crystal piezo-electricity substrate by ultraviolet curing mold resin as shown in the pages 51 of the collection of the 20th supersonic-wave symposium drafts (November, 1999).

[0004]

[Problem(s) to be Solved by the Invention] A cellular phone etc. is in the

inclination for each frequency band of transmission and reception to be expanded more, from a rapid commercial-scene expansion in recent years, and the system with very narrow frequency spacing of a transmitting band and a receiving band also exists. Much more high performance-ization is demanded also from the various devices built in a cellular phone etc. from this. Especially in the conventional surface acoustic element which forms the Kushigata crossed electrode of a metal thin film on single crystal piezo-electricity substrates, such as a lithium tantalate substrate or a lithium-niobate substrate, when a time delay temperature coefficient is large, since the magnitude of attenuation between bands cannot fully be taken, it becomes a serious technical problem.

[0005] The time delay temperature coefficient of a surface acoustic element is determined by the difference of the line coefficient of thermal expansion of a single crystal piezo-electricity substrate, and the temperature coefficient of surface acoustic wave velocity of propagation. If these values are values of a single crystal piezo-electricity substrate proper and it says about a line coefficient of thermal expansion For example, the X-axis of the lithium tantalate substrate which has Men bearing rotated at the include angle of 36 degrees - 46 degrees in Z shaft orientations from a Y-axis focusing on the X-axis, That is, it is large in degree C and about 15.4 ppm /, the X-axis, i.e., surface acoustic wave propagation direction, of a lithium-niobate substrate which has Men bearing rotated at the include angle of 64 degrees in Z shaft orientations from a Y-axis in the surface acoustic wave propagation direction focusing on about 16.1 ppm [degree C] /and the X-axis. This point has been a failure when aiming at improvement in the engine performance of a surface acoustic element from now on.

[0006] As an approach of solving the above-mentioned technical problem, there is an approach using the compound piezo-electricity substrate which joined the glass substrate with a small line coefficient of thermal expansion to the single crystal piezo-electricity substrate directly. However, since the above-mentioned compound piezo-electricity substrate has joined the substrate with which the

quality of the materials differ, especially, its effect of bulk wave reflection by the substrate junction interface is large, and it has the problems (a filter for example, the ripple in a band or a spurious response out of band etc.) which degrade the property of a surface acoustic element.

[0007] Moreover, although there is also a method of using adhesives etc. in addition to said direct junction about the substrate junction approach, there is no thermal resistance in applicable adhesives, and there is a possibility that a problem may arise, at the time of heat-treatment in the process which forms a device.

[0008] This invention aims at realizing a surface acoustic element on the substrate for surface acoustic elements whose time delay temperature coefficient can improve, and its substrate for surface acoustic elements by improving the line coefficient of thermal expansion of the single crystal piezo-electricity substrate which carries out excitation propagation of the surface acoustic wave in consideration of the above problems.

[0009] Namely, it aims at realizing substrate junction which shows sufficient thermal resistance and chemical resistance to the manufacture process process of the Kushigata crossed electrode after substrate junction in the approach of performing substrate junction through a glue line for the purpose of realizing the good surface acoustic wave propagation property of having suppressed the effect of bulk wave reflection by the substrate junction interface in the direct conjugation method, about the conjugation method of a single crystal piezo-electricity substrate and.

[0010]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the surface acoustic element by this invention In the structure equipped with the tandem-type crossed electrode which is formed on the plane of composition of the 1st substrate which is a single crystal piezo-electricity substrate, the 2nd substrate joined to the 1st substrate, and the 2nd substrate of the 1st substrate, and Men of the opposite side, and carries out excitation propagation of the

surface acoustic wave It is characterized by making the surface acoustic wave propagation direction of the 1st substrate a direction and parallel with the smallest line coefficient of thermal expansion in the plane of composition of the 2nd substrate.

[0011] As for the quality of the material of the above 1st and the 2nd substrate, in a configuration of that the 2nd substrate is substantially joined to the 1st directly without a junctional zone, in the above, it is desirable that it is the same quality of the material. Moreover, when it is the configuration that the above 1st and the 2nd substrate by this invention joined the dissimilar material, in order to enable substrate junction which solved the heat-resistant and chemical-resistant problem, it is desirable to junction mind [of a substrate] the glue line which uses spreading glass as a principal component.

[0012]

[Embodiment of the Invention] Drawing 1 is the perspective view showing the 1st example of the surface acoustic element by this invention. The 2nd substrate with which 1 of drawing was joined to the single crystal piezo-electricity substrate, and 2 was joined to the above-mentioned substrate 1, and 3 are the tandem-type crossed electrodes formed on a plane of composition with the substrate 2 of the above-mentioned substrate 1, and Men of the opposite side. In this example, although the quality of the material of a substrate 2 is the same as a substrate 1, the line coefficient of thermal expansion of the substrate 2 in the propagation direction (arrow head 4) of the surface acoustic wave of a substrate 1 is joined so that it may become smaller than the line coefficient of thermal expansion of this direction of a substrate 1.

[0013] In the surface acoustic element in this example, the substrate which the substrate 1 and the substrate 2 were joined by direct junction, and was joined is used as a substrate 5 for surface acoustic elements. The surface acoustic wave excited with the tandem-type crossed electrode 3 formed on the substrate 1 spreads a substrate 1 top, and is functioning as a surface acoustic element. Since the electrode finger of the Kushigata crossed electrode 3 is perpendicularly

formed to the X-axis of a substrate 1, a surface acoustic wave is spread in the parallel direction to the X-axis of a substrate 1.

[0014] In the surface acoustic element in which the Kushigata crossed electrode 3 of a metal thin film was formed on the substrate 1, the difference of the line coefficient of thermal expansion of the surface acoustic wave propagation direction 4 of a substrate 1 and the temperature coefficient of surface acoustic wave velocity of propagation determines a time delay temperature coefficient. The line coefficient of thermal expansion of the surface acoustic wave propagation direction 4 (X shaft orientations) of a lithium tantalate substrate with Men bearing which these values are values of a single crystal piezo-electricity substrate proper, for example, was rotated from the Y-axis at the include angle of 36 degrees - 46 degrees to Z shaft orientations focusing on the X-axis is not a numeric value good in degree C and about 16.1 ppm /.

[0015] In the single crystal piezo-electricity substrate currently used for current and a surface acoustic element, the Xtal substrate is one of those have a good time delay temperature coefficient. In the case of the Xtal substrate, the line coefficient of thermal expansion of the surface acoustic wave propagation direction 4 is not a value with good degree C, about 13.71 ppm /, and ******, but since the temperature coefficient of surface acoustic wave velocity of propagation has the property in which a lithium tantalate substrate, a lithium-niobate substrate, etc. serve as a forward value conversely, the value of a line coefficient of thermal expansion is offset by the value of the temperature coefficient of surface acoustic wave velocity of propagation, and a time delay temperature coefficient shows a small value. However, the Xtal substrate has the fault that an electromechanical coupling coefficient is small and sufficient frequency bandwidth cannot be obtained. Now, the single crystal piezo-electricity substrate with both both an electromechanical coupling coefficient and a good time delay temperature coefficient is not discovered.

[0016] In this example, in order that a time delay temperature coefficient may realize a small surface acoustic element using a single crystal piezo-electricity

substrate with a large electromechanical coupling coefficient, the surface acoustic wave propagation direction 4 of the substrate 1 which is a single crystal piezo-electricity substrate, and the direction where the line coefficient of thermal expansion of the 2nd substrate 2 is small are made parallel, and it joins. Thereby, the line coefficient of thermal expansion of a substrate 1 is controlled by the line coefficient of thermal expansion of a substrate 2, and a time delay temperature coefficient is improved with it.

[0017] Drawing 2 shows an example of Men bearing of the substrate 1 by this example, and drawing 3 shows an example of Men bearing of the substrate 2 by this example. The arrow head 6 of drawing 3 shows the direction where the coefficient of thermal expansion of the 2nd substrate is the smallest. Here, the lithium tantalate substrate which has Men bearing of Y shaft orientations as a substrate 2 which becomes Z shaft orientations from the same quality of the material as a substrate 1 using a lithium tantalate substrate with Men bearing rotated at the include angle of 36 degrees - 46 degrees is used from a Y-axis focusing on the X-axis as a substrate 1.

[0018] Drawing 4 is drawing having shown the junction direction in the case of joining a substrate 1 and a substrate 2. Here, the line coefficient of thermal expansion of a substrate 1 and a substrate 2 is considered. In the lithium tantalate substrate which has Men bearing rotated at the include angle of 36 degrees - 46 degrees in Z shaft orientations from a Y-axis focusing on the X-axis which is a substrate 1, the line coefficient of thermal expansion of X shaft orientations which are the propagation directions 4 of a surface acoustic wave is about 16.1 ppm/degree C. On the other hand, the direction where the coefficient of thermal expansion of a lithium tantalate substrate with Men bearing of Y shaft orientations which are substrates 2 is very small (an arrow head 6 shows.) The line coefficient of thermal expansion of Z shaft orientations which intersect perpendicularly to X shaft orientations which are the propagation directions of a surface acoustic wave here is the smallest in degree C, about 4.1 ppm /, and this field.

[0019] Since according to this invention the line coefficient of thermal expansion of a substrate 1 is controlled by the line coefficient of thermal expansion of a substrate 2 by making parallel X shaft orientations which are the surface acoustic wave propagation directions 4 of a substrate 1, and the Z shaft orientations 6 with the very small line coefficient of thermal expansion of a substrate 2, and joining as shown in drawing 4 , the line coefficient of thermal expansion of the surface acoustic wave propagation direction 4 is improvable. However, since the line coefficient of thermal expansion of a substrate 1 does not necessarily turn into a line coefficient of thermal expansion of a substrate 2 as it is and serves as a numeric value according to the thermal stress produced in a plane of composition by the differential thermal expansion of a substrate 1 and a substrate 2, the substrate thickness of a substrate 1 and a substrate 2 becomes important. As a result of inquiring, by sheet-metal-izing a substrate 1 so that the thickness of a substrate 2 may become 3 or more times of the thickness of a substrate 1 showed that the line coefficient of thermal expansion of the surface acoustic wave propagation direction could be improved more notably in the joined substrate 5 for surface acoustic elements.

[0020] By here setting to 270 micrometers board thickness of the lithium tantalate substrate which has Men bearing of Y shaft orientations which are 90 micrometers and a substrate 2 about the board thickness of a lithium tantalate substrate with Men bearing rotated at the include angle of 36 degrees - 46 degrees in Z shaft orientations from a Y-axis a core [the X-axis which is a substrate 1], the line coefficient of thermal expansion of a lithium tantalate substrate with Men bearing of Y shaft orientations becomes dominant, and a line coefficient of thermal expansion is improved. As a result of measuring the time delay temperature coefficient in this case, it was 24 ppm/degree C. Since the time delay temperature coefficient of the conventional surface acoustic element which does not perform substrate junction was 33 ppm/degree C, it had a 9 ppm [/degree C] improvement effect by this invention. Moreover, larger effectiveness is acquired by making board thickness of a substrate 1 much more thin.

[0021] Moreover, since it is the structure, i.e., the structure where the lattice constant in a junction interface becomes the same, where the substrate 1 and substrate 2 which were joined consist of the same quality of the material according to this example, as compared with junction of a dissimilar-material substrate which is represented by a single crystal piezo-electricity substrate and the glass substrate, more powerful adhesive strength is realizable. Namely, implementation of very powerful adhesive strength is possible for the lithium tantalate substrate which has Men bearing with Men bearing rotated at the include angle of 36 degrees - 46 degrees of a lithium tantalate substrate and Y shaft orientations in Z shaft orientations from a Y-axis focusing on the X-axis from being the same quality of the material.

[0022] The effect of bulk wave reflection of the substrate junction interface by this example is explained using drawing 5 . If board thickness of a substrate 1 is sheet-metal-ized so that the thickness of a substrate 2 may become 3 or more times of the thickness of a substrate 1, in order that the front face and substrate junction interface of a substrate 1 may approach, as shown in (a), the effect of the reflected wave 8 from the substrate junction interface of a bulk wave 7 will become larger. However, since according to this example it is the structure where the joined substrate 1 and the joined substrate 2 consist of the same quality of the material as shown in (b), as compared with the case where a dissimilar-material substrate is joined, the effect of the reflected wave 8 from the substrate junction interface of a bulk wave 7 becomes small.

[0023] That is, the lithium tantalate substrate which has Men bearing with Men bearing rotated at the include angle of 36 degrees - 46 degrees of a lithium tantalate substrate and Y shaft orientations in Z shaft orientations from a Y-axis focusing on the X-axis has the small effect by reflection by the junction interface since it is the same quality of the material, and degradation of the component property by the bulk wave reflection from a junction interface can be made small in the surface acoustic wave of this example which has this structure.

[0024] Moreover, since the joined substrates 1 and 2 are the same quality of the

materials according to this example although it is easy to produce the problem of substrate breakage with the difference of the line coefficient of thermal expansion of a junction substrate, the ununiformity of the thermal stress of the void section and a joint, etc. when joining dissimilar-material substrates directly, as compared with direct junction of a dissimilar-material substrate, it is hard to produce the problem of substrate breakage.

[0025] Drawing 6 explains an example of the manufacture approach of the surface acoustic element of this invention below. For example, as a substrate 1, the lithium tantalate substrate which has Men bearing rotated at the include angle of 36 degrees - 46 degrees in Z shaft orientations and by which mirror polishing was carried out is prepared from a Y-axis focusing on the X-axis. Moreover, the lithium tantalate substrate which has Men bearing of Y shaft orientations as a substrate 2 and by which mirror polishing was carried out is prepared. Heat treatment of 1 hours or more is performed at the temperature of 300 degrees C or more as pretreatment which joins above-mentioned both. This is performed in order to remove gas and the organic substance adhering to the front face of a substrate 1 and a substrate 2. If this processing is neglected, a void may occur in a junction interface after substrate junction.

[0026] Subsequently, after making the solution which mixed pure water (H2O) with the hydrogen peroxide (H2O2) and the aqueous ammonia solution (NH4OH) for two lithium tantalate substrates to join immersed about about 10 minutes, the rinse by pure water is performed. This gives a hydrophilic property to the front face of a substrate 1 and a substrate 2, and has the effectiveness combined according to the Juan Dell Wace force committed between the water molecules by which the substrate front face is adsorbed at the time of substrate junction.

[0027] Then, after drying two lithium tantalate substrates, substrate junction is performed in a room temperature and an air ambient atmosphere. Especially the thing for which a particle free-lancer's junction interface is acquired here is important, and it is desirable to perform substrate junction in the clean room which has a ten or more-class air cleanliness class after said washing. Moreover,

a particle free-lancer's interface and an interface with a hydrophilic property can be reconciled by washing just before junction.

[0028] Then, two joined lithium tantalate substrates perform sheet metal-ization of the lithium tantalate substrate which has Men bearing rotated at the include angle of 36 degrees - 46 degrees in Z shaft orientations from a Y-axis focusing on the X-axis which is a substrate 1 so that the line coefficient of thermal expansion of a lithium tantalate substrate with Men bearing of Y shaft orientations which are substrates 2 may become dominant. It grinds so that it may become 1/3 or less from a Y-axis to the board thickness of a lithium tantalate substrate with Men bearing of Y shaft orientations using substrate polish equipment about the board thickness of the lithium tantalate substrate which has Men bearing rotated at the include angle of 36 degrees - 46 degrees in Z shaft orientations focusing on the X-axis.

[0029] A polish process performs finishing polish gradually from rough polish, and realizes mirror polishing. At this time, as shown here, it does not sheet-metal-ize according to the polish process after substrate junction. You may join, after preparing the lithium tantalate substrate which has Men bearing rotated at the include angle of 36 degrees - 46 degrees in Z shaft orientations from a Y-axis focusing on the X-axis which becomes 1/3 or less board thickness to the lithium tantalate substrate which has Men bearing of Y shaft orientations beforehand. Especially a process will not be asked if the board thickness of a substrate 1 is 1/3 or less board thickness to the board thickness of a substrate 2.

[0030] After sheet-metal-izing a substrate 1, two lithium tantalate substrates are completely joined by performing heat treatment of about 2 hours at the temperature of 250 degrees C. Then, it produces by performing the usual electrode making process on the substrate 1 joined to the substrate 2 in the Kushigata crossed electrode 3 as shown in drawing 7 . The Kushigata crossed electrode 3 is arranged so that the surface acoustic wave by which excitation propagation is carried out with the Kushigata crossed electrode 3 at this time may be in agreement with the surface acoustic wave propagation direction (X

shaft orientations) of a substrate 1.

[0031] Although the example using the lithium tantalate substrate which has Men bearing rotated from the Y-axis at the include angle of 36 degrees - 46 degrees to Z shaft orientations focusing on the X-axis as a substrate 1 in the above and the 1st example, and the lithium tantalate substrate which has Men bearing of Y shaft orientations as substrates 2 which consist of the same quality of the material was explained Also when the lithium tantalate substrate which has Men bearing of X shaft orientations as a substrate 2 is used, there is same effectiveness.

[0032] Also when it joins so that similarly X shaft orientations of a substrate 2 and X shaft orientations of a substrate 1 may cross [as a substrate 1] at right angles using a lithium tantalate substrate with the field bearing same as a substrate 2 which becomes Z shaft orientations from the same quality of the material using a lithium tantalate substrate with Men bearing rotated at the include angle of 36 degrees - 46 degrees as a substrate 1 from a Y-axis focusing on the X-axis, there is same effectiveness.

[0033] Also when it joins so that the direction rotated at the include angle of 112 degrees to Z shaft orientations may become parallel to Z shaft orientations of a substrate 2 from the Y-axis which is the surface acoustic wave propagation direction 4 of a substrate 1 using the lithium tantalate substrate which has Men bearing of Y shaft orientations or X shaft orientations as a substrate 2 which similarly consists of the same quality of the material using the lithium tantalate substrate which has Men bearing of X shaft orientations as a substrate 1, there is same effectiveness.

[0034] Also when it joins so that similarly X shaft orientations of a substrate 1 may be parallel to Z shaft orientations of a substrate 2 from a Y-axis using the lithium-niobate substrate which has Men bearing of Y shaft orientations or X shaft orientations as a substrate 2 which becomes Z shaft orientations from the same quality of the material using a lithium-niobate substrate with Men bearing rotated at the include angle of 41 degrees - 64 degrees focusing on the X-axis as a

substrate 1, there is same effectiveness.

[0035] Also when it joins so that similarly X shaft orientations of a substrate 2 and X shaft orientations of a substrate 1 may cross [as a substrate 1] at right angles using a lithium-niobate substrate with the field bearing same as a substrate 2 which becomes Z shaft orientations from the same quality of the material using a lithium-niobate substrate with Men bearing rotated at the include angle of 41 degrees - 64 degrees as a substrate 1 from a Y-axis focusing on the X-axis, there is same effectiveness.

[0036] Moreover, there is same effectiveness also in the substrate 5 for surface acoustic elements joined so that the surface acoustic wave propagation direction 4 of a substrate 1 might become parallel to the direction of a c-axis of a substrate 2 using the tetraboric-acid lithium substrate which has a c-axis in a plane of composition as a substrate 2 which consists of the same quality of the material, using a tetraboric-acid lithium substrate as a substrate 1.

[0037] Considering the line coefficient of thermal expansion of the substrate 1 in this case, and a substrate 2, the line coefficient of thermal expansion of the c-axis of the tetraboric-acid lithium substrate which is a substrate 2 is [about] to the line coefficient of thermal expansion of the direction of an a-axis of the tetraboric-acid lithium substrate which is a substrate 1 being about 13 ppm/degree C. -It becomes a line coefficient of thermal expansion negative in degree C and 1.5 ppm /. Therefore, degree C is [about / of the line coefficient of thermal expansion of the direction of a c-axis] in about 13 ppm /of the line coefficient of thermal expansion of the direction of an a-axis by carrying out substrate junction so that the direction of an a-axis of a tetraboric-acid lithium substrate and the direction of a c-axis of a tetraboric-acid lithium substrate may become parallel. -It is controlled by degree C in 1.5 ppm /, and the line coefficient of thermal expansion of the surface acoustic wave propagation direction can be improved in the joined substrate 5 for surface acoustic elements.

[0038] Below, another example of this invention is explained. Drawing 8 is the perspective view showing the 2nd example of the surface acoustic element by

this invention. The surface acoustic element shown in drawing 8 is a surface acoustic element equipped with the tandem-type crossed electrode 3 which is formed on the plane of composition of the substrate 1 which is a single crystal piezo-electricity substrate, the substrate 2 joined to the substrate 1, and the substrate 2 of a substrate 1, and Men of the opposite side, and excites a surface acoustic wave, and has the glue line 9 which uses spreading glass (SOG:Spin On Grass) as a principal component at the junction interface of a substrate 1 and a substrate 2 in junction of a substrate 1 and a substrate 2.

[0039] The line coefficient of thermal expansion of the substrate 2 in the propagation direction 4 of the surface acoustic wave of a substrate 1 is joined so that it may become smaller than the line coefficient of thermal expansion of this direction of a substrate 1. Moreover, board thickness of a substrate 1 is sheet-metal-ized so that the thickness of a substrate 2 may become 3 or more times of the thickness of a substrate 1. The substrate to which the substrate 1 and the substrate 2 were joined, using spreading glass as a glue line 9 is used as a substrate 5 for surface acoustic elements. The surface acoustic wave excited with the tandem-type crossed electrode 3 formed on the substrate 1 spreads a substrate 1 top, and functions as a surface acoustic element.

[0040] The spreading glass used as a glue line 9 can form the coat which uses oxidation silicon as a principal component by the method of applying / calcinating, and dissolves a silicon compound in an organic solvent. Here, an oxidation silicon substrate is used [as a substrate 1] for Z shaft orientations as a substrate 2 using a lithium tantalate substrate with Men bearing rotated at the include angle of 36 degrees - 46 degrees from a Y-axis focusing on the X-axis.

[0041] By using the spreading glass with which a principal component consists of oxidation silicon as a glue line 9 in junction of a substrate 1 and a substrate 2 according to this example Since there is no aggravation of the time delay temperature coefficient by the glue line 9 in the comparison with the case where ultraviolet curing mold resin etc. is used as adhesives, for example from the time delay temperature coefficient of glue line 9 the very thing being small, The time

delay temperature coefficient to the surface acoustic wave propagation direction 4 of the joined substrate 5 for surface acoustic elements is improved more. Moreover, since a principal component consists of oxidation silicon, a degree of hardness is very high, and also when the stress by the thermal expansion of a substrate 1 occurs, spreading glass can control the elongation of the piezo-electric substrate 1 compared with ultraviolet curing mold resin etc., and is effective also for an improvement of a line coefficient of thermal expansion.

[0042] Since the substrate 5 for surface acoustic elements which joined the substrate 1 and the substrate 2 has a metal thin film covering process, a phot lithography processes, an etching process, and a process accompanied by heat treatment of a solder reflow process etc. in a back process as a manufacture process which produces a surface acoustic element in a last process further after substrate junction, it becomes important [thermal resistance]. Moreover, in each process, since organic, an inorganic chemical, etc. are used, chemical resistance also becomes important. Therefore, in joining a substrate 1 and a substrate 2 using a glue line 9, thermal resistance and chemical resistance become indispensable at a glue line 9.

[0043] As an example, the case where ultraviolet curing mold resin is used for a glue line 9 is explained. Since ultraviolet curing mold resin hardens only by irradiating ultraviolet rays and substrate junction is completed after applying ultraviolet curing mold resin to the plane of composition of a substrate 2 and performing substrate junction, heat treatment is also an unnecessary very simple substrate conjugation method. However, although chemical resistance is enough as a property of ultraviolet curing mold resin, since thermal resistance is as low as about 120 degrees C, the application as a glue line 9 is difficult.

[0044] As another example, the case where heat-curing mold resin is used for a glue line 9 is explained. The substrate 2 with which heat-curing mold resin was applied after having applied heat-curing mold resin to the plane of composition of a substrate 2, volatilizing the solvent by heat treatment and making it harden is heated again, where heat-curing mold resin is softened, a substrate 1 is joined,

by cooling after substrate junction, heat-curing mold resin is stiffened and junction is completed. However, as a property of heat-curing mold resin, chemical resistance is brittle, and, for a certain reason, it is also difficult for the application as a glue line 9 to soften by reheating after substrate junction further.

[0045] As still more nearly another example, the case where the wax for adhesion is used for a glue line 9 is explained. It is the very simple substrate junction approach that apply the wax for adhesion to the plane of composition of the substrate 2 heated with the hot plate etc., stiffen the wax for adhesion by cooling after the wax for adhesion has melted and joining a substrate 1, and junction is completed. However, since there is no chemical resistance in addition to thermal resistance being low as a property of the wax for adhesion so that alcohol also melts, the application as a glue line 9 is difficult.

[0046] The spreading glass with which the principal component used as a glue line 9 consists of oxidation silicon in this example in case a substrate 1 and a substrate 2 are joined In order to show the high resistance which showed sufficient thermal resistance also in heat treatment of 400 degrees C or more, and applied to oxidation silicon correspondingly also about chemical resistance, It is not necessary to compare with the case where said ultraviolet curing mold resin, heat-curing mold resin, the wax for adhesion, etc. are used for a glue line, sufficient thermal resistance and chemical resistance are shown also to the manufacture process process of the Kushigata crossed electrode 3, a solder reflow process, etc., and powerful adhesive strength can be maintained.

[0047] The difference of the line coefficient of thermal expansion of the surface acoustic wave propagation direction 4 of a single crystal piezo-electricity substrate and the temperature coefficient of surface acoustic wave velocity of propagation determines the time delay temperature coefficient of a surface acoustic element as above-mentioned. If its attention is paid to the temperature coefficient of surface acoustic wave velocity of propagation here, since it has a property used as a negative value, with a lithium tantalate substrate or a lithium-niobate substrate, the time delay temperature coefficient decided by the

difference with a line coefficient of thermal expansion will get worse more.

[0048] On the other hand, since a principal component consists of oxidation silicon, the spreading glass used as a glue line 9 in this example serves as a value forward in the temperature coefficient of surface acoustic wave velocity of propagation, and the time delay temperature coefficient decided by the difference with a line coefficient of thermal expansion improves. By using this property that spreading glass has, it is possible to offset each other with the value of the temperature coefficient of the surface acoustic wave velocity of propagation in which the spreading glass of a glue line 9 has the value of the line coefficient of thermal expansion of a substrate 1.

[0049] That is, the time delay temperature coefficient of the surface acoustic wave propagation direction 4 of the joined substrate 5 for surface acoustic elements can be improved by optimizing the thickness of a glue line 9 so that the temperature coefficient of the elastic wave velocity of propagation which the glue line 9 which uses spreading glass as a principal component has may serve as a value which offsets the coefficient of thermal expansion of the elastic wave surface wave propagation direction 4 of a substrate 1.

[0050] Moreover, in the joined substrate 5 for surface acoustic elements, the line coefficient of thermal expansion of the surface acoustic wave propagation direction 4 is improvable by joining so that the surface acoustic wave propagation direction 4 of a substrate 1 may become parallel to the c-axis of a substrate 2 as this example using the tetraboric-acid lithium substrate which has a c-axis in a plane of composition as a substrate 2 in the substrate 5 for surface acoustic elements which has the glue line 9 which uses spreading glass as a principal component in the junction interface of a substrate 1 and a substrate 2.

[0051] The line coefficient of thermal expansion of the c-axis of a tetraboric-acid lithium substrate is [about] as mentioned above. -In order to show a line coefficient of thermal expansion negative in degree C and 1.5 ppm /, it is because the line coefficient of thermal expansion of a substrate 1 can improve more greatly.

[0052] Moreover, the substrate 1 which is a single crystal piezo-electricity substrate as another operation gestalt of this example, In the surface acoustic element equipped with the tandem-type crossed electrode 3 which is formed on the plane of composition of the substrate 2 joined to the substrate 1 by the glue line 9 which uses spreading glass as a principal component, and the substrate 2 of a substrate 1, and Men of the opposite side, and excites a surface acoustic wave If a diamond substrate with surface acoustic wave velocity of propagation very high-speed as a substrate 2 is used, since the velocity of propagation of the surface acoustic wave by which excitation propagation is carried out in the surface acoustic element formed on the joined substrate 1 will become quick, it is effective to RF-izing. Furthermore, for a certain reason, the thermal conductivity of a surface acoustic element becomes high, and the property of power-proof nature of the Kushigata crossed electrode 3 in which thermal conductivity is very high to the diamond substrate used for the substrate 2 can also improve.
[0053] Drawing 9 explains an example of the manufacture approach of the surface acoustic element of this example below. For example, heat treatment of 1 hours or more is performed for the lithium tantalate substrate which has Men bearing rotated at the include angle of 36 degrees - 46 degrees in Z shaft orientations, and the diamond substrate which is used as a substrate 2 and by which mirror polishing was carried out at the temperature of 300 degrees C or more as pretreatment of junction from a Y-axis focusing on the X-axis which is used as a substrate 1 and by which mirror polishing was carried out.
[0054] Subsequently, after making the solution which mixed pure water (H_2O) with the hydrogen peroxide (H_2O_2) and the aqueous ammonia solution (NH_4OH) for the lithium tantalate substrate to join and the diamond substrate immersed about about 10 minutes, the rinse by pure water is performed. After drying two substrates, the process which carries out substrate junction through spreading glass as a glue line 9 is performed. Rotation spreading of the spreading glass is carried out first in the plane of composition of a diamond substrate.
[0055] Then, the diamond substrate which applied spreading glass is heated

about 5 minutes on the hot plate heated at about 80 degrees C. This is performed in order to evaporate the organic solvent which is the solvent of spreading glass. After carrying out grade heating for 5 minutes, the plane of composition of a lithium tantalate substrate and the spreading glass spreading side of a diamond substrate are joined on a hot plate. Especially the thing for which a particle free-lancer's junction interface is acquired here is important, and it is desirable to perform substrate junction in a clean room with a ten or more-class air cleanliness class.

[0056] The air bubbles of a substrate junction interface are completely removed by putting a pressure on a lithium tantalate substrate and a diamond substrate after substrate junction. Then, the joined substrate 5 for surface acoustic elements performs sheet metal-ization of the lithium tantalate substrate 1 so that the line coefficient of thermal expansion of a diamond substrate may become dominant. Using substrate polish equipment (not shown), the board thickness of the lithium tantalate substrate 1 is ground so that it may become 1/3 or less to the board thickness of the diamond substrate 2. The above-mentioned polish process performs finishing polish gradually from rough polish, and realizes mirror polishing. In addition, about thin-film-izing of a substrate, it does not adhere to the aforementioned approach, and especially a process will not be asked if the board thickness of a substrate 1 is 1/3 or less board thickness to the board thickness of a substrate 2.

[0057] After sheet-metal-izing a lithium tantalate substrate, two substrates are completely joined by performing heat treatment for 20 minutes at the temperature of 150 degrees C, and performing heat treatment of about 1 hour at the temperature of 200 more degrees C.

[0058] Then, it produces by performing the usual electrode making process on the lithium tantalate substrate 1 joined to the diamond substrate 2 through the glue line 9 according the Kushigata crossed electrode 3 as shown in drawing 10 to spreading glass. The Kushigata crossed electrode 3 is arranged so that the surface acoustic wave by which excitation propagation is carried out with the

Kushigata crossed electrode 3 at this time may be in agreement with the surface acoustic wave propagation direction 4 (X shaft orientations) of a substrate 1.

[0059] Although the 2nd example of the above explained the lithium tantalate substrate which has Men bearing rotated at the include angle of 36 degrees - 46 degrees in Z shaft orientations from the Y-axis focusing on the X-axis as a substrate 1 Also when the lithium-niobate substrate which has Men bearing rotated at an angle of the range of 41-64 degrees is used for Z shaft orientations from a Y-axis as a substrate 1 focusing on the lithium tantalate which makes the X-axis field bearing, or the X-axis, there is same effectiveness.

[0060] Moreover, although the 2nd example of the above explained the oxidization silicon substrate, the diamond substrate, and the tetraboric-acid lithium substrate as a substrate 2, it has the same effectiveness also in the substrate by alumimium nitride, silicon, silicon nitride, boron, oxidization boron, boron nitride, lithium tantalate, lithium niobate, or those composite material.

[0061]

[Effect of the Invention] As explained above, the structure which makes parallel the direction where a coefficient of thermal expansion is the smallest, and is joined in the elastic wave surface wave propagation direction of the 1st substrate which carries out excitation propagation of the surface acoustic wave in this invention, and the plane of composition of the 2nd substrate which consists of the same ingredient as the 1st substrate was proposed. Thereby, a line coefficient of thermal expansion is improved and a time delay temperature coefficient becomes producible [a small surface acoustic element].

[0062] Moreover, very powerful adhesive strength can be realized and the effect of bulk wave reflection by the junction interface becomes producible [a small surface acoustic element] from it being the structure where the 1st joined substrate and 2nd joined substrate consist of the same quality of the material further. Moreover, it is effective in generating of substrate breakage decreasing as compared with the case where a dissimilar-material substrate is joined directly by joining of-the-same-kind ingredient substrates directly.

[0063] Moreover, in this invention, the approach of using spreading glass for junction of the 1st substrate and the 2nd substrate as a glue line was proposed. By using spreading glass, the substrate junction which has thermal resistance and chemical resistance becomes realizable by the simple and cheap approach, and since substrates with all properties, such as a substrate with a small line coefficient of thermal expansion, a substrate with quick surface acoustic wave velocity of propagation, and a substrate with high thermal conductivity, can be used as the 2nd substrate, a property improvement of a surface acoustic element is attained.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The perspective view of the surface acoustic element by the 1st example of this invention.
[Drawing 2] The explanatory view showing an example of field bearing of the 1st substrate by the 1st example of this invention.
[Drawing 3] The explanatory view showing an example of field bearing of the 2nd substrate by the 1st example of this invention.

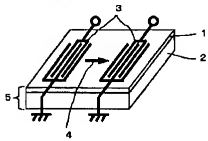
[Drawing 4] The explanatory view showing the junction direction of the substrate for surface acoustic elements by the 1st example of this invention.
[Drawing 5] The explanatory view showing the bulk wave reflection by the junction interface of the substrate for surface acoustic elements.
[Drawing 6] The sectional view showing the production process of the substrate for surface acoustic elements by the 1st example of this invention.
[Drawing 7] The sectional view of the surface acoustic element by the 1st example of this invention.
[Drawing 8] The perspective view of the surface acoustic element by the 2nd example of this invention.
[Drawing 9] The sectional view showing the production process of the substrate for surface acoustic elements by the 2nd example of this invention.
[Drawing 10] The sectional view of the surface acoustic element by the 2nd example of this invention.
[Description of Notations]
1 [-- The surface acoustic wave propagation direction of the 1st substrate, 5 / -- The substrate for surface acoustic elements, 6 / -- The direction where the coefficient of thermal expansion of the 2nd substrate is the smallest 7 / -- A bulk wave, 8 / -- A reflected wave, 9 / -- Glue line.] -- The 1st substrate, 2 -- The 2nd substrate, 3 -- The Kushigata crossed electrode, 4

[Translation done.]

DRAWINGS

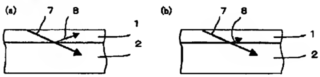
[Drawing 1]

図1



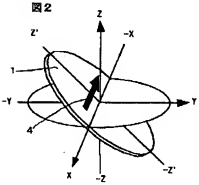
[Drawing 5]

図5

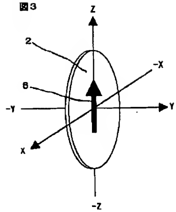


[Drawing 2]

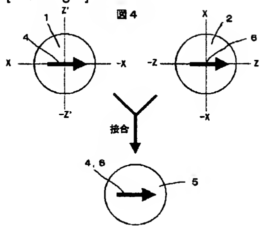
図2



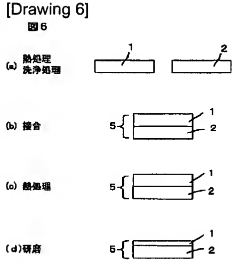
[Drawing 3]



[Drawing 4]

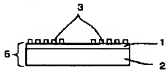


[Drawing 6]



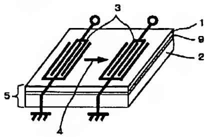
[Drawing 7]

図７



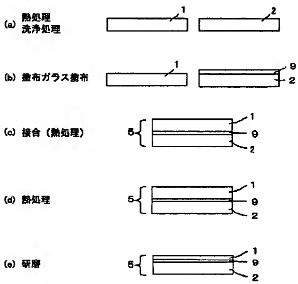
[Drawing 8]

図８



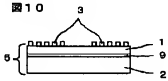
[Drawing 9]

図９



[Drawing 10]

図１０



[Translation done.]

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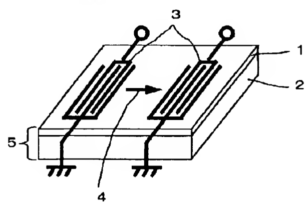
最終頁に続く

(54)【発明の名称】弾性表面波素子

(57)【要約】
【課題】弾性表面波素子における遅延時間温度係数を小さくする。
【解決手段】線熱膨張係数を改善するために、同じ材質からなる複数の単結晶圧電基板を、弾性表面波の伝搬方向と線熱膨張係数の小さい方向を平行にして接合する、あるいは異種材料からなる接合基板において、接着層として耐熱性が高く、取扱いが容易な塗布ガラスを用いる。

図１



【特許請求の範囲】

【請求項１】単結晶圧電基板である第１の基板と、前記第１の基板に接合された第２の基板と、前記第１の基板の前記第２の基板との接合面と反対側の面上に形成され弾性波を励振する櫛型交差電極とを備えた弾性表面波素子において、前記第２の基板は前記第１の基板と同一材質の基板であり、前記第１の基板の前記弾性波の伝搬方向における前記第２の基板の熱膨張係数は、前記第１の基板の同方向の熱膨張係数より小さいことを特徴とする弾性表面波素子。

【請求項２】請求項１記載の弾性表面波素子において、前記第２の基板の厚さは前記第１の基板の厚さの３倍以上であることを特徴とする弾性表面波素子。

【請求項３】請求項１または２記載の弾性表面波素子において、前記第１および第２の基板はタンタル酸リチウムであり、前記第２の基板のＺ軸は前記第２の基板の接合面内に存在し、前記第１の基板の前記弾性波の伝搬方向は前記第２の基板のＺ軸と平行であることを特徴とする弾性表面波素子。

【請求項４】請求項１または２記載の弾性表面波素子において、前記第１および第２の基板はタンタル酸リチウムであり、前記第１の基板の面方位はＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の範囲の角度で回転された方向であり、前記第２の基板の面方位はＹ軸方向もしくはＸ軸方向であり、前記第１の基板の前記弾性波の伝搬方向は前記第１の基板のＸ軸方向であり、前記第１の基板のＸ軸は前記第２の基板のＺ軸と平行であることを特徴とする弾性表面波素子。

【請求項５】請求項１または２記載の弾性表面波素子において、前記第１および第２の基板はタンタル酸リチウムであり、前記第１および第２の基板の面方位はＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の範囲の角度で回転された方向であり、前記第１の基板の前記弾性波の伝搬方向は前記第１の基板のＸ軸方向であり、前記第１の基板のＸ軸は前記第２の基板のＸ軸と直交することを特徴とする弾性表面波素子。

【請求項６】請求項１または２記載の弾性表面波素子において、前記第１および前記第２の基板はタンタル酸リチウムであり、前記第１の基板の面方位はＸ軸方向であり、前記第２の基板の面方位はＹ軸方向もしくはＸ軸方向であり、前記第１の基板の前記弾性波の伝搬方向は前記第１の基板のＹ軸からＺ軸方向に１１２°の角度で回転された方向であり、前記第１の基板のＹ軸からＺ軸方向に１１２°の角度で回転された方向は前記第２の基板のＺ軸と平行であることを特徴とする弾性表面波素子。

【請求項７】請求項１または２記載の弾性表面波素子において、前記第１および前記第２の基板はニオブ酸リチウムであり、前記第２の基板のＺ軸は前記第２の基板の接合面内に存在し、前記第１の基板の前記弾性波の伝搬方向は前記第２の基板のＺ軸と平行であることを特徴とする弾性表面波素子。

【請求項８】請求項１または２記載の弾性表面波素子において、前記第１および前記第２の基板はニオブ酸リチウムであり、前記第１の基板の面方位はＸ軸を中心にＹ軸からＺ軸方向に４１～６４°の範囲の角度で回転された方向であり、前記第２の基板の面方位はＹ軸方向もしくはＸ軸方向であり、前記第１の基板の前記弾性波の伝搬方向は前記第１の基板のＸ軸方向であり、前記第１の基板のＸ軸は前記第２の基板のＺ軸と平行であることを特徴とする弾性表面波素子。

【請求項９】請求項１または２記載の弾性表面波素子において、前記第１および前記第２の基板はニオブ酸リチウムであり、前記第１および前記第２の基板の面方位はＸ軸を中心にＹ軸からＺ軸方向に４１～６４°の範囲の角度で回転された方向であり、前記第１の基板の前記弾性波の伝搬方向は前記第１の基板のＸ軸方向であり、前記第１の基板のＸ軸は前記第２の基板のＸ軸と直交することを特徴とする弾性表面波素子。

【請求項１０】請求項１または２記載の弾性表面波素子において、前記第２の基板は四ホウ酸リチウム単結晶であり、前記第２の基板の四ホウ酸リチウム単結晶のｃ軸は前記第２の基板の接合面内に存在し、前記第１の基板の前記弾性波の伝搬方向は前記第２の基板の四ホウ酸リチウム単結晶のｃ軸と平行であることを特徴とする弾性表面波素子。

【請求項１１】請求項１ないし１０のいずれか記載の弾性表面波素子において、前記第１の基板と前記第２の基板の接合は、前記第１の基板と前記第２の基板の接合界面に塗布ガラスを主成分とする接着層を有することを特徴とする弾性表面波素子。

【請求項１２】単結晶圧電基板である第１の基板と、前記第１の基板に接合された第２の基板と、前記第１の基板の前記第２の基板との接合面と反対側の面上に形成され弾性波を励振する櫛型交差電極とを備えた弾性表面波素子において、塗布ガラスを主成分とする接着層を接合界面に有し、前記第２の基板の厚さは前記第１の基板の厚さの３倍以上であることを特徴とする弾性表面波素子。

【請求項１３】請求項１２項記載の弾性表面波素子において、前記塗布ガラスを主成分とする接着層が有する弾性波伝搬速度の温度係数が、前記第１の基板の前記弾性波の伝搬方向の熱膨張係数を相殺する値となるように、塗布ガラス層の膜厚を最適化したことを特徴とする弾性表面波素子。

【請求項１４】請求項１１ないし１３記載の弾性表面波素子用の基板を製造する方法であって、前記第１および前記第２の基板を熱処理した後に洗浄する第１工程と、前記第１もしくは前記第２の基板の接合面に塗布ガラス膜を塗布した後、加熱により塗布ガラス膜の溶剤を蒸発させる第２工程と、前記第１の基板と前記第２の基板を

接合させる第３工程と、基板接合後に加熱処理を行う第４工程により、前記第１の基板と前記第２の基板を塗布ガラス層を介して接合することを特徴とする弾性表面波素子用基板の製造方法。

【請求項１５】請求項１２または１３記載の弾性表面波素子において、前記第１の基板は、Ｘ軸を中心にＹ軸からＺ軸方向に３６°〜４６°の範囲の角度で回転された面方位を有するタンタル酸リチウム、Ｘ軸を面方位とするタンタル酸リチウム、またはＸ軸を中心にＹ軸からＺ軸方向に４１〜６４°の範囲の角度で回転された面方位を有するニオブ酸リチウムであることを特徴とする弾性表面波素子。

【請求項１６】請求項１２または１３記載の弾性表面波素子において、前記第２の基板は、ダイヤモンド、窒化アルミニウム、珪素、酸化珪素、窒化珪素、硼素、酸化硼素、窒化硼素、タンタル酸リチウム、ニオブ酸リチウム、四ホウ酸リチウムのいずれかまたはそれらの複合材料からなることを特徴とする弾性表面波素子。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は携帯電話等に用いられる弾性表面波を用いる素子およびその基板の製造方法に関する。

【０００２】

【従来の技術】携帯電話等に用いられる弾性表面波素子は、例えば、電子情報通信学会論文誌Ａ，Ｊ７６巻−Ａ，２号、１８５−１９２頁（１９９３年２月）に示されているように、タンタル酸リチウム基板、ニオブ酸リチウム基板および四ホウ酸リチウム基板などの単結晶圧電基板上に金属薄膜の櫛形交差電極を形成して構成されている。

【０００３】携帯電話等の高性能化に伴い、それらに用いる弾性表面波素子用基板の遅延時間温度係数を改善させた報告がなされている。例えば、特開平１１−５５０７０号に示されているように単結晶圧電基板とガラス基板を直接接合させた事例がある。さらに、第２０回超音波シンポジウム予稿集５１頁（１９９９年１１月）に示されているように単結晶圧電基板とマイナス膨張ガラスを紫外線硬化型樹脂で接合させた事例がある。

【０００４】

【発明が解決しようとする課題】携帯電話等は、近年の急速な市場拡大から、送受信の各周波数帯域がより拡大される傾向にあり、送信帯域と受信帯域の周波数間隔が非常に狭いシステムも存在している。このことから携帯電話等に内蔵される各種デバイスに対しても、より一層の高性能化が要求されている。特にタンタル酸リチウム基板あるいはニオブ酸リチウム基板等の単結晶圧電基板上に金属薄膜の櫛形交差電極を形成する従来の弾性表面波素子では、遅延時間温度係数が大きい場合、帯域間減衰量が十分に取れないため重大な課題となる。

【０００５】弾性表面波素子の遅延時間温度係数は、単結晶圧電基板の線熱膨張係数と弾性表面波伝搬速度の温度係数との差によって決定される。これらの値は単結晶圧電基板固有の値であり、線熱膨張係数に関して言えば、例えばＸ軸を中心にＹ軸からＺ軸方向に３６°〜４６°の角度で回転された面方位を持つタンタル酸リチウム基板のＸ軸、すなわち弾性表面波伝搬方向では約１６．１ｐｐｍ／℃、またＸ軸を中心にＹ軸からＺ軸方向に６４°の角度で回転された面方位を持つニオブ酸リチウム基板のＸ軸すなわち弾性表面波伝搬方向では約１５．４ｐｐｍ／℃と大きい。今後、弾性表面波素子の性能向上を図る上でこの点が障害となっている。

【０００６】上記の課題を解決する方法として、単結晶圧電基板に線熱膨張係数が小さいガラス基板を直接接合した複合圧電基板を用いる方法がある。しかし、上記複合圧電基板は材質の異なる基板を接合しているため、特に基板接合界面でのバルク波反射の影響が大きく、弾性表面波素子の特性を劣化させる問題（フィルタでは例えば帯域内リップル、あるいは帯域外のスプリアス応答等）がある。

【０００７】また、基板接合方法に関しては、前記直接接合以外に、接着剤等を用いる方法もあるが、適用できる接着剤に耐熱性がなく、デバイスを形成する過程での加熱処理時に問題が生じるおそれがある。

【０００８】本発明は、上記のような問題を考慮し、弾性表面波を励振伝搬させる単結晶圧電基板の線熱膨張係数を改善することによって、遅延時間温度係数が向上できる弾性表面波素子用基板、およびその弾性表面波素子用基板上に弾性表面波素子を実現することを目的とする。

【０００９】すなわち、単結晶圧電基板の接合法に関しては、直接接合法において基板接合界面でのバルク波反射の影響を抑えた良好な弾性表面波伝搬特性を実現することを目的とし、また接着層を介して基板接合を行う方法において基板接合後の櫛形交差電極の製造プロセス工程に対して十分な耐熱性および耐薬品性を示す基板接合を実現することを目的とする。

【００１０】

【課題を解決するための手段】上記目的を達成するために、本発明による弾性表面波素子は、単結晶圧電基板である第１の基板と、第１の基板に接合された第２の基板と、第１の基板の第２の基板との接合面と反対側の面上に形成され弾性表面波を励振伝搬する櫛型交差電極とを備えた構造において、第１の基板の弾性表面波伝搬方向を第２の基板の接合面内で最も線熱膨張係数の小さい方向と平行にすることを特徴とする。

【００１１】上記において、第１と第２の基板が実質的に接合層を介さず、直接接合される構成の場合、上記第１と第２の基板の材質は、同じ材質であることが好ましい。また、本発明による上記第１と第２の基板が異種材

料を接合した構成であるときには、耐熱性および耐薬品性の問題を解決した基板接合を可能とするために、基板の接合界面に塗布ガラスを主成分とする接着層を介することが好ましい。

【００１２】

【発明の実施の形態】図１は本発明による弾性表面波素子の第１の実施例を示す斜視図である。図の１は単結晶圧電基板、２は上記基板１に接合された第２の基板、３は上記基板１の、基板２との接合面と反対側の面上に形成された櫛型交差電極である。本実施例において、基板２の材質は基板１と同じであるが、基板１の弾性表面波の伝搬方向（矢印４）における基板２の線熱膨張係数は、基板１の同方向の線熱膨張係数より小さくなるように接合されている。

【００１３】本実施例における弾性表面波素子では、基板１と基板２とが直接接合によって接合され、接合した基板を弾性表面波素子用基板５として用いる。基板１上に形成された櫛型交差電極３により励振された弾性表面波は基板１上を伝搬し、弾性表面波素子として機能している。櫛形交差電極３の電極指は基板１のＸ軸に対して垂直方向に形成されているため、弾性表面波は基板１のＸ軸に対して平行な方向に伝搬する。

【００１４】基板１上に金属薄膜の櫛形交差電極３を形成した弾性表面波素子において遅延時間温度係数は、基板１の弾性表面波伝搬方向４の線熱膨張係数と弾性表面波伝搬速度の温度係数との差によって決定する。これらの値は単結晶圧電基板固有の値であり、例えば、Ｘ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板の弾性表面波伝搬方向４（Ｘ軸方向）の線熱膨張係数は約１６．１ｐｐｍ／℃と良好な数値ではない。

【００１５】現在、弾性表面波素子に使用されている単結晶圧電基板において、遅延時間温度係数が良好なものとしては水晶基板がある。水晶基板の場合、弾性表面波伝搬方向４の線熱膨張係数は約１３．７１ｐｐｍ／℃と、けして良好な値ではないが、弾性表面波伝搬速度の温度係数がタンタル酸リチウム基板やニオブ酸リチウム基板などとは逆に正の値となる性質を持っているため、線熱膨張係数の値が弾性表面波伝搬速度の温度係数の値によって相殺され、遅延時間温度係数が小さな値を示す。しかしながら、水晶基板は電気機械結合係数が小さく、十分な周波数帯域幅を得ることができないという欠点がある。電気機械結合係数と遅延時間温度係数の両方がともに良好な単結晶圧電基板は、現在のところ発見されていない。

【００１６】本実施例では、電気機械結合係数が大きい単結晶圧電基板を用いて、遅延時間温度係数が小さい弾性表面波素子を実現するために、単結晶圧電基板である基板１の弾性表面波伝搬方向４と第２の基板２の線熱膨張係数の小さい方向とを平行にして接合する。これにより、基板２の線熱膨張係数によって基板１の線熱膨張係数が抑制され、遅延時間温度係数が改善される。

【００１７】図２は本実施例による基板１の面方位の一例を示したものであり、図３は本実施例による基板２の面方位の一例を示したものである。図３の矢印６は、第２の基板の熱膨張係数が最も小さい方向を示す。ここでは基板１としてＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板を用い、基板１と同じ材質からなる基板２としてＹ軸方向の面方位を持つタンタル酸リチウム基板を用いる。

【００１８】図４は、基板１と基板２を接合させる場合の接合方向を示した図である。ここで、基板１および基板２の線熱膨張係数を考える。基板１であるＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板では、弾性表面波の伝搬方向４であるＸ軸方向の線熱膨張係数が約１６．１ｐｐｍ／℃である。これに対して、基板２であるＹ軸方向の面方位を持つタンタル酸リチウム基板の熱膨張係数が非常に小さい方向（矢印６で示す。ここでは弾性表面波の伝搬方向であるＸ軸方向に対して直交するＺ軸方向）の線熱膨張係数は約４．１ｐｐｍ／℃と、この面内で最も小さい。

【００１９】本発明によると図４に示すように、基板１の弾性表面波伝搬方向４であるＸ軸方向と、基板２の線熱膨張係数が非常に小さいＺ軸方向６を平行にして接合することにより、基板１の線熱膨張係数が基板２の線熱膨張係数によって抑制されるため、弾性表面波伝搬方向４の線熱膨張係数を改善することができる。ただし、基板１の線熱膨張係数がそのまま基板２の線熱膨張係数となるわけではなく、基板１と基板２の熱膨張差によって接合面に生じる熱応力に準じた数値となるため、基板１と基板２の基板厚さが重要となる。検討した結果、基板２の厚さが基板１の厚さの３倍以上となるように基板１を薄板化することにより、接合した弾性表面波素子用基板５において弾性表面波伝搬方向の線熱膨張係数をより顕著に改善できることが分かった。

【００２０】ここでは、基板１であるＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板の板厚を９０μm、基板２であるＹ軸方向の面方位を持つタンタル酸リチウム基板の板厚を２７０μmとすることにより、Ｙ軸方向の面方位を持つタンタル酸リチウム基板の線熱膨張係数が支配的となり、線熱膨張係数が改善される。この場合の遅延時間温度係数を測定した結果、２４ｐｐｍ／℃であった。基板接合を行わない従来の弾性表面波素子の遅延時間温度係数は３３ｐｐｍ／℃であるから、本発明により９ｐｐｍ／℃の改善効果があった。また、基板１の板厚をより一層薄くすることで、より大きい効果が得られる。

【００２１】また、本実施例によれば、接合された基板１と基板２が同じ材質からなる構造、すなわち接合界面における格子定数が同じとなる構造であるため、単結晶圧電基板とガラス基板に代表されるような異種材料基板の接合と比較して、より強力な接着力が実現できる。すなわち、Ｘ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板とＹ軸方向の面方位を持つタンタル酸リチウム基板は同じ材質であることから、非常に強力な接着力の実現が可能である。

【００２２】図５を用いて本実施例による基板接合界面のバルク波反射の影響を説明する。基板２の厚さが基板１の厚さの３倍以上となるように基板１の板厚を薄板化すると、基板１の表面と基板接合界面とが接近するために（ａ）に示すようにバルク波７の基板接合界面からの反射波８の影響がより大きくなる。しかしながら、本実施例によれば（ｂ）に示すように、接合した基板１と基板２が同じ材質からなる構造であるため、異種材料基板を接合した場合と比較して、バルク波７の基板接合界面からの反射波８の影響が小さくなる。

【００２３】すなわち、Ｘ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板とＹ軸方向の面方位を持つタンタル酸リチウム基板は、同じ材質であることから接合界面での反射による影響が小さく、この構造を有する本実施例の弾性表面波では接合界面からのバルク波反射による素子特性の劣化を小さくすることができる。

【００２４】また、異種材料基板どうしを直接接合する場合には、接合基板の線熱膨張係数の差やボイド部と接合部との熱応力の不均一などにより、基板破損の問題が生じやすいが、本実施例によれば、接合された基板１と２が同じ材質であるため、異種材料基板の直接接合と比較して基板破損の問題が生じにくい。

【００２５】つぎに本発明の弾性表面波素子の製造方法の一例を図６により説明する。例えば基板１として、Ｘ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つ鏡面研磨されたタンタル酸リチウム基板を用意する。また、基板２としてはＹ軸方向の面方位を持つ鏡面研磨されたタンタル酸リチウム基板を用意する。上記両者を接合する前処理として３００℃以上の温度で１時間以上の熱処理を行う。これは基板１および基板２の表面に付着しているガスや有機物を除去する目的で行う。この処理を怠ると基板接合後に接合界面にボイドが発生する可能性がある。

【００２６】次いで、接合する２枚のタンタル酸リチウム基板を、過酸化水素（H_2O_2）とアンモニア水溶液（NH_4OH）と純水（H_2O）を混合した溶液に約１０分程度浸漬させた後、純水によるリンスを行う。これは基板１および基板２の表面に親水性を持たせ、基板接合時に基板表面に吸着されている水分子間に働くファンデルワース力により結合させる効果がある。

【００２７】その後、２枚のタンタル酸リチウム基板を乾燥させた後、室温、空気雰囲気中で基板接合を行う。ここではパーティクルフリーの接合界面を得ることが特に重要であり、前記洗浄後、クラス１０以上のクリーン度を持つクリーンルームで基板接合を行うことが望ましい。また、接合直前に洗浄を行うことによりパーティクルフリーの界面と親水性を持った界面を両立させることができる。

【００２８】その後、接合された２枚のタンタル酸リチウム基板は基板２であるＹ軸方向の面方位を持つタンタル酸リチウム基板の線熱膨張係数が支配的となるように、基板１であるＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板の薄板化を行う。基板研磨装置を用いて、Ｘ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板の板厚を、Ｙ軸方向の面方位を持つタンタル酸リチウム基板の板厚に対して３分の１以下となるように研磨する。

【００２９】研磨工程は粗研磨から仕上げ研磨を段階的に行い、鏡面研磨を実現する。このとき、ここに示したように基板接合後の研磨工程によって薄板化するのではなく、あらかじめＹ軸方向の面方位を持つタンタル酸リチウム基板に対して３分の１以下の板厚となるＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板を用意してから接合してもよく、基板１の板厚が基板２の板厚に対して３分の１以下の板厚であれば製法は特に問わない。

【００３０】基板１を薄板化した後、２５０℃の温度で約２時間の熱処理を行うことにより２枚のタンタル酸リチウム基板は完全に接合される。その後、図７に示すような櫛形交差電極３を、基板２に接合された基板１上に通常の電極作製工程を行って作製する。このとき櫛形交差電極３により励振伝搬される弾性表面波が基板１の弾性表面波伝搬方向（Ｘ軸方向）と一致するように櫛形交差電極３を配置する。

【００３１】上記、第１の実施例においては、基板１としてＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板、同じ材質からなる基板２としてＹ軸方向の面方位を持つタンタル酸リチウム基板を用いた例について説明したが、基板２としてＸ軸方向の面方位を持つタンタル酸リチウム基板を用いた場合も同様の効果がある。

【００３２】同様に、基板１としてＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板を用い、同じ材質からなる基板２として基板１と同じ面方位を持つタンタル酸リチウム基板を用い、基板１のＸ軸方向が基板２のＸ軸方向と直交するように接合した場合も同様の効果がある。

【００３３】同様に、基板１としてＸ軸方向の面方位を

持つタンタル酸リチウム基板を用い、同じ材質からなる基板２としてＹ軸方向もしくはＸ軸方向の面方位を持つタンタル酸リチウム基板を用い、基板１の弾性表面波伝搬方向４であるＹ軸からＺ軸方向に１１２°の角度で回転された方向が基板２のＺ軸方向と平行となるように接合した場合も同様の効果がある。

【００３４】同様に、基板１としてＸ軸を中心にＹ軸からＺ軸方向に４１°～６４°の角度で回転された面方位を持つニオブ酸リチウム基板を用い、同じ材質からなる基板２としてＹ軸方向もしくはＸ軸方向の面方位を持つニオブ酸リチウム基板を用い、基板１のＸ軸方向が基板２のＺ軸方向と平行するように接合した場合も同様の効果がある。

【００３５】同様に、基板１としてＸ軸を中心にＹ軸からＺ軸方向に４１°～６４°の角度で回転された面方位を持つニオブ酸リチウム基板を用い、同じ材質からなる基板２として基板１と同じ面方位を持つニオブ酸リチウム基板を用い、基板１のＸ軸方向が基板２のＸ軸方向と直交するように接合した場合も同様の効果がある。

【００３６】また、基板１として四ホウ酸リチウム基板を用い、同じ材質からなる基板２として接合面内にｃ軸を有する四ホウ酸リチウム基板を用い、基板１の弾性表面波伝搬方向４が基板２のｃ軸方向と平行となるように接合した弾性表面波素子用基板５においても同様の効果がある。

【００３７】この場合の基板１および基板２の線熱膨張係数を考えると、基板１である四ホウ酸リチウム基板のａ軸方向の線熱膨張係数が約１３ｐｐｍ／℃であるのに対して、基板２である四ホウ酸リチウム基板のｃ軸の線熱膨張係数は約－１．５ｐｐｍ／℃と負の線熱膨張係数となる。よって、四ホウ酸リチウム基板のａ軸方向と四ホウ酸リチウム基板のｃ軸方向が平行となるように基板接合することにより、ａ軸方向の線熱膨張係数の約１３ｐｐｍ／℃がｃ軸方向の線熱膨張係数の約－１．５ｐｐｍ／℃によって抑制され、接合した弾性表面波素子用基板５において弾性表面波伝搬方向の線熱膨張係数が改善できる。

【００３８】つぎに、本発明の別の実施例を説明する。図８は本発明による弾性表面波素子の第２の実施例を示す斜視図である。図８に示す弾性表面波素子は単結晶圧電基板である基板１と、基板１に接合された基板２と、基板１の基板２との接合面と反対側の面上に形成され弾性表面波を励振する櫛型交差電極３とを備えた弾性表面波素子であり、基板１と基板２の接合には基板１と基板２の接合界面に塗布ガラス（ＳＯＧ：Spin On Grass）を主成分とする接着層９を有している。

【００３９】基板１の弾性表面波の伝搬方向４における基板２の線熱膨張係数は、基板１の同方向の線熱膨張係数より小さくなるように接合されている。また、基板２の厚さが基板１の厚さの３倍以上となるように基板１の板厚が薄板化されている。接着層９として塗布ガラスを用いて基板１と基板２を接合させた基板を弾性表面波素子用基板５として用いる。基板１上に形成された櫛型交差電極３により励振された弾性表面波は基板１上を伝搬し、弾性表面波素子として機能する。

【００４０】接着層９として用いる塗布ガラスは酸化珪素を主成分とする被膜を塗布・焼成法で形成することができるもので、珪素化合物を有機溶剤に溶解させたものである。ここでは基板１としてＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板を用い、基板２として酸化珪素基板を用いる。

【００４１】本実施例によれば、基板１と基板２の接合において、接着層９として主成分が酸化珪素からなる塗布ガラスを用いることにより、接着層９自体の遅延時間温度係数が小さいことから、例えば紫外線硬化型樹脂等を接着剤として用いた場合との比較において、接着層９による遅延時間温度係数の悪化がないため、接合した弾性表面波素子用基板５の弾性表面波伝搬方向４に対する遅延時間温度係数がより改善される。また、塗布ガラスは主成分が酸化珪素からなるため非常に硬度が高く、基板１の熱膨張による応力が発生した場合にも、例えば紫外線硬化型樹脂等と比べて圧電基板１の伸びを抑制することができ、線熱膨張係数の改善にも効果的である。

【００４２】基板１と基板２を接合した弾性表面波素子用基板５は基板接合後に弾性表面波素子を作製する製造プロセスとして、前工程においては金属薄膜被着工程、ホトリソグラフィー工程、エッチング工程、さらに後工程においては半田リフロー工程などの熱処理を伴う工程を有するため、耐熱性が重要となる。また、各工程において、有機および無機薬品なども使用されるため耐薬品性も重要となる。よって、接着層９を用いて基板１と基板２を接合させる場合には接着層９に耐熱性および耐薬品性が必須となる。

【００４３】一例として、接着層９に紫外線硬化型樹脂を用いた場合について説明する。基板２の接合面に紫外線硬化型樹脂を塗布し基板接合を行った後、紫外線を照射するだけで紫外線硬化型樹脂が硬化して基板接合が完了するため、熱処理も不要な非常に簡便な基板接合法である。しかし、紫外線硬化型樹脂の特性として耐薬品性は十分であるが、耐熱性が１２０℃程度と低いため接着層９としての適用は難しい。

【００４４】別の例として、接着層９に熱硬化型樹脂を用いた場合について説明する。基板２の接合面に熱硬化型樹脂を塗布し、熱処理により溶剤を揮発させ硬化させた後、熱硬化型樹脂が塗布された基板２を再び加熱し、熱硬化型樹脂を軟化させた状態で基板１を接合し、基板接合後に冷却することにより熱硬化型樹脂を硬化させ、接合が完了する。しかし、熱硬化型樹脂の特性としては耐薬品性が脆弱で、さらに基板接合後の再加熱により軟

化することもあるため接着層９としての適用は難しい。

【００４５】さらに別の例として、接着層９に接着用ワックスを用いた場合について説明する。ホットプレートなどで加熱した基板２の接合面に接着用ワックスを塗り、接着用ワックスが溶けた状態で基板１を接合した後、冷却することにより接着用ワックスを硬化させ、接合が完了するという非常に簡便な基板接合方法である。しかしながら、接着用ワックスの特性としては耐熱性が低いことにくわえて、アルコールでも溶けるほど耐薬品性がないため接着層９としての適用は難しい。

【００４６】本実施例において、基板１と基板２を接合する際に接着層９として用いる主成分が酸化珪素からなる塗布ガラスは、４００℃以上の熱処理においても十分な耐熱性を示し、また耐薬品性に関しても酸化珪素に準じた高い耐性を示すため、前記紫外線硬化型樹脂、熱硬化型樹脂、接着用ワックス等を接着層に使用した場合と比較するまでもなく、櫛形交差電極３の製造プロセス工程、半田リフロー工程等に対しても十分な耐熱性、耐薬品性を示し、強力な接着力が維持できる。

【００４７】弾性表面波素子の遅延時間温度係数は、前述のとおり単結晶圧電基板の弾性表面波伝搬方向４の線熱膨張係数と弾性表面波伝搬速度の温度係数との差によって決定する。ここで弾性表面波伝搬速度の温度係数に着目すると、タンタル酸リチウム基板やニオブ酸リチウム基板等では負の値となる性質を持っているため、線熱膨張係数との差により決まる遅延時間温度係数はより悪化する。

【００４８】これに対して、本実施例において接着層９として用いる塗布ガラスは主成分が酸化珪素からなるため、弾性表面波伝搬速度の温度係数が正の値となり、線熱膨張係数との差により決まる遅延時間温度係数は向上する。塗布ガラスが有するこの性質を利用することにより、基板１の線熱膨張係数の値を接着層９の塗布ガラスが有する弾性表面波伝搬速度の温度係数の値によって相殺することが可能である。

【００４９】つまり、塗布ガラスを主成分とする接着層９が有する弾性波伝搬速度の温度係数が、基板１の弾性波表面波伝搬方向４の熱膨張係数を相殺する値となるように、接着層９の膜厚を最適化することにより、接合した弾性表面波素子用基板５の弾性表面波伝搬方向４の遅延時間温度係数が改善できることになる。

【００５０】また本実施例として、基板１と基板２の接合界面に塗布ガラスを主成分とする接着層９を有する弾性表面波素子用基板５において、基板２として接合面内にｃ軸を有する四ホウ酸リチウム基板を用い、基板１の弾性表面波伝搬方向４が基板２のｃ軸と平行となるように接合することにより、接合した弾性表面波素子用基板５において弾性表面波伝搬方向４の線熱膨張係数が改善できる。

【００５１】四ホウ酸リチウム基板のｃ軸の線熱膨張係数は前述のように約－１．５ｐｐｍ／℃と負の線熱膨張係数を示すため、基板１の線熱膨張係数がより大きく改善できるためである。

【００５２】また本実施例の別の実施形態として、単結晶圧電基板である基板１と、基板１に塗布ガラスを主成分とする接着層９により接合された基板２と、基板１の基板２との接合面と反対側の面上に形成され弾性表面波を励振する櫛型交差電極３とを備えた弾性表面波素子において、基板２として弾性表面波伝搬速度が非常に高速であるダイアモンド基板を用いると、接合した基板１上に形成された弾性表面波素子において励振伝搬される弾性表面波の伝搬速度が速くなるため、高周波化に対して効果がある。さらに、基板２に用いたダイアモンド基板には熱伝導性が非常に高いという性質もあるため、弾性表面波素子の熱伝導率が高くなり、櫛形交差電極３の耐電力性も向上できる。

【００５３】つぎに本実施例の弾性表面波素子の製造方法の一例を図９により説明する。例えば基板１として用いる鏡面研磨されたＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板と、基板２として用いる鏡面研磨されたダイアモンド基板を、接合の前処理として３００℃以上の温度で１時間以上の熱処理を行う。

【００５４】次いで、接合するタンタル酸リチウム基板とダイアモンド基板を過酸化水素（H_2O_2）とアンモニア水溶液（NH_4OH）と純水（H_2O）を混合した溶液に約１０分程度浸漬させた後、純水によるリンスを行う。２枚の基板を乾燥させた後、接着層９として塗布ガラスを介して基板接合する工程を行う。まずダイアモンド基板の接合面に塗布ガラスを回転塗布する。

【００５５】その後、塗布ガラスを塗布したダイアモンド基板を８０℃程度に加熱したホットプレート上で５分程度加熱する。これは塗布ガラスの溶媒である有機溶剤を蒸発させるために行なう。５分間程度加熱した後、ホットプレート上でタンタル酸リチウム基板の接合面とダイアモンド基板の塗布ガラス塗布面とを接合させる。ここではパーティクルフリーの接合界面を得ることが特に重要であり、クラス１０以上のクリーン度を持つクリーンルームで基板接合を行うことが望ましい。

【００５６】基板接合後、タンタル酸リチウム基板とダイアモンド基板に圧力をかけることで基板接合界面の気泡を完全に除去する。その後、接合された弾性表面波素子用基板５は、ダイアモンド基板の線熱膨張係数が支配的となるようにタンタル酸リチウム基板１の薄板化を行う。基板研磨装置（図示せず）を用いて、タンタル酸リチウム基板１の板厚をダイアモンド基板２の板厚に対して３分の１以下となるように研磨する。上記研磨工程は、粗研磨から仕上げ研磨を段階的に行い、鏡面研磨を実現する。なお、基板の薄膜化に関しては前記の方法にこだわるものではなく、基板１の板厚が基板２の板厚に

対して３分の１以下の板厚であれば製法は特に問わない。

【００５７】タンタル酸リチウム基板を薄板化した後、１５０℃の温度で２０分の熱処理を行い、さらに２００℃の温度で約１時間程度の熱処理を行なうことにより、２枚の基板は完全に接合される。

【００５８】その後、図１０に示すような櫛形交差電極３を、塗布ガラスによる接着層９を介してダイアモンド基板２に接合されたタンタル酸リチウム基板１上に、通常の電極作製工程を行って作製する。このとき櫛形交差電極３により励振伝搬される弾性表面波が基板１の弾性表面波伝搬方向４（Ｘ軸方向）と一致するように櫛形交差電極３を配置する。

【００５９】上記第２の実施例は、基板１としてＸ軸を中心にＹ軸からＺ軸方向に３６°～４６°の角度で回転された面方位を持つタンタル酸リチウム基板について説明したが、基板１としてＸ軸を面方位とするタンタル酸リチウム、もしくはＸ軸を中心にＹ軸からＺ軸方向に４１～６４°の範囲の角度で回転された面方位を有するニオブ酸リチウム基板を用いた場合も同様の効果がある。

【００６０】また上記第２の実施例は、基板２として酸化珪素基板、ダイアモンド基板および四ホウ酸リチウム基板について説明したが、窒化アルミニウム、珪素、窒化珪素、硼素、酸化硼素、窒化硼素、タンタル酸リチウム、ニオブ酸リチウム、またはそれらの複合材料による基板においても同様な効果がある。

【００６１】

【発明の効果】以上に説明したように、本発明において弾性表面波を励振伝搬させる第１の基板の弾性波表面波伝搬方向と、第１の基板と同じ材料からなる第２の基板の接合面内で最も熱膨張係数の小さい方向とを平行にして接合する構造を提案した。これにより、線熱膨張係数が改善され、遅延時間温度係数が小さい弾性表面波素子の作製が可能となる。

【００６２】また、接合した第１の基板と第２の基板が同じ材質からなる構造であることから、非常に強力な接着力の実現でき、さらには接合界面でのバルク波反射の影響が小さい弾性表面波素子の作製が可能となる。また、同種材料基板どうしを直接接合することにより、異種材料基板を直接接合する場合と比較して基板破損の発生が減少するという効果もある。

【００６３】また、本発明において、第１の基板と第２の基板の接合に、塗布ガラスを接着層として用いる方法を提案した。塗布ガラスを用いることにより、耐熱性、耐薬品性を有する基板接合が簡便かつ安価な方法により実現が可能となり、線熱膨張係数の小さい基板、弾性表面波伝搬速度の速い基板、および熱伝導率が高い基板など、あらゆる特性を持つ基板を第２の基板として用いることができるため弾性表面波素子の特性改善が可能となる。

【図面の簡単な説明】

【図１】本発明の第１の実施例による弾性表面波素子の斜視図。

【図２】本発明の第１の実施例による第１の基板の面方位の一例を示す説明図。

【図３】本発明の第１の実施例による第２の基板の面方位の一例を示す説明図。

【図４】本発明の第１の実施例による弾性表面波素子用基板の接合方向を示す説明図。

【図５】弾性表面波素子用基板の接合界面でのバルク波反射を示す説明図。

【図６】本発明の第１の実施例による弾性表面波素子用基板の製造工程を示す断面図。

【図７】本発明の第１の実施例による弾性表面波素子の断面図。

【図８】本発明の第２の実施例による弾性表面波素子の斜視図。

【図９】本発明の第２の実施例による弾性表面波素子用基板の製造工程を示す断面図。

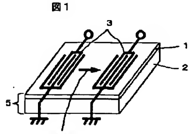
【図１０】本発明の第２の実施例による弾性表面波素子の断面図。

【符号の説明】

１…第１の基板、２…第２の基板、３…櫛形交差電極、４…第１の基板の弾性表面波伝搬方向、５…弾性表面波素子用基板、６…第２の基板の熱膨張係数が最も小さい方向、７…バルク波、８…反射波、９…接着層。

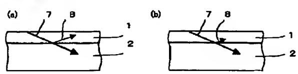
【図１】

図１

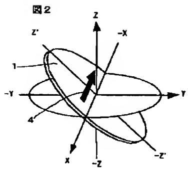


【図５】

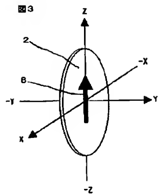
図５



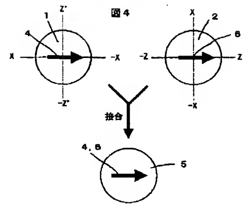
【図２】



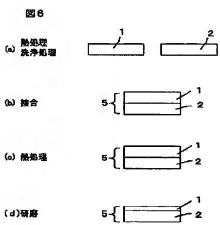
【図３】



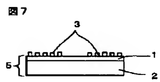
【図４】



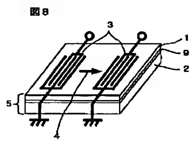
【図６】



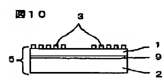
【図７】



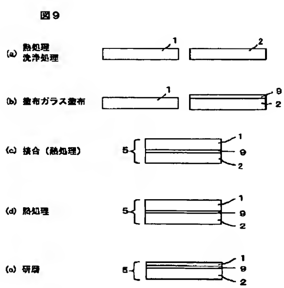
【図８】



【図１０】



【図９】



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